Near Earth Object Search
With
Ground Based Electro-Optical Deep Space Surveillance System
(GEODSS)

John Darrah
Air Force Space Command

Detection of near-Earth objects (NEOs) includes the broad functions of identifying, characterizing, and cataloguing potentially threatening comets and asteroids. These functions can be accomplished for objects larger than 1 km using a few dedicated 1 to 2 meter telescopes. However, the key parameter to enabling such functions for the whole sky with any degree of speed is the search rate of the instruments used to collect and process the data. Search rates of reasonable magnitude to cover the whole sky suggest the use of advanced CCD detector focal planes. The Air Force has developed and is continuing to explore such capabilities in upgrading their Ground Based Electro-Optical Deep Space Surveillance System (GEODSS). Recently the Spacewatch Telescope on Kitt Peak, operated by the Universtity of Arizona with backing from the Air Force Office of Scientific Research, has discovered and begun to exploring a new population of 10 meter to 300 meter asteroids which have a more frequent arrival rate of once in a thousand years and energy equivalent to upwards of a hundred megatons. This changes broadens the potential threat and illustrates the need to also consider a warning system for threats of a size that would incur regional damage.

Development of the Ground Based Electro-Optical Deep Space Surveillance System (GEODSS)

The United States Air Force has a relatively long history of advocacy, funding, technical involvement, and operational experience with the types of systems essential to planetary defense. Front end technological capabilities needed to effectively perform such a mission include wide field of view sensors with rapid search capability, techniques for identifying moving targets in a cluttered background, and a continuously updated data base of positional and other information on all space objects. These are the same capabilities required and used by the Air Force since the beginning of the space age. Initiated in response to Sputnick, the Air Force space surveillance program has maintained a world wide network of sensors tasked to track the location of all manmade space objects. The development of the current, wide field-of-view optical search systems used by the USAF started with the Prairie Network Optics designed by Baker. These optics and technologies were incorporated in the Baker-Nunn telescope which the Smithsonian Astronomical Observatory designed for the tracking of satellites. The Baker-Nunn system was turned over to the Air Force in Colorado Springs to incorporate into their space surveillance system in 1961. In 1970 the Air Force started research and development (R&D) that led to the replacement of the Baker-Nunn optical system with the Ground Based Electro-Optical Deep Space Surveillance System (GEODSS). GEODSS used the Epsicon tube as a detector instead of film.

Large Format Charge Coupled Devices (CCDs)

Epsicon tube technology was and continues to be very successful in space surveillance applications. The current GEODSS, which was designed to have very high search rates, is an interesting design, which differs from most astronomical telescopes, mounts, cameras, and processors. The Air Force has invested nearly $200 million since 1970 in this R&D effort. But the space surveillance task load continues to grow. Today, for example, the Air Force space surveillance system processes approximately 50,000 observations each and every day and maintains orbital parameters for between seven and eight thousand man-made objects in orbit around the earth. In 1972 the Air Force started the development of solid state detectors that led to large format Charge Coupled Devices imaging cameras. These are the same devices used in spacecraft for detectors in the visible, infrared, and x-ray bands. The Air Force developed this technology and is testing it for incorporation in GEODSS as a potential modernization of part of its global space surveillance system.

Efforts to develop commercial CCDs began after a 1981 review in Washington D.C. encouraged the Spacewatch Program to develop new CCD-scanning techniques on an existing 0.9-meter Newtonian telescope contributed by the Steward Observatory of the University of Arizona. Surveying began in 1984 with a RCA 320 X 512 CCD. Though useful for other tasks, it lacked the area coverage required to detect near-Earth asteroids. In 1988, a 2048 X 2048 Tektronix CCD was delivered and near-Earth asteroids could be found.

Near Earth Object (NEO) Search

This large format Charge Coupled Devices technology appears to have significant capabilities in searching the whole sky for detecting and tracking non-man-made objects such as asteroids and comets. The Spacewatch surveying program currently finds about 25,000 asteroids per year generating their astrometric positions good to +/- 0.5 arcseconds. This surveying effort was the first to discover an entirely new population of smaller asteroids in the 10 meter to 300 meter range. The mass of these asteroids could impact with upwards of a hundred megatons of energy. This defines a threat level below the global catastrophe that would occur in the case of sizable long period comet but considerable enough to cause major regional damage particularly through tsunamis if impact occurs in a broad ocean area. The asteroids in this size range are more numerous and calculated to strike the earth with a frequency close to once every thousand years.

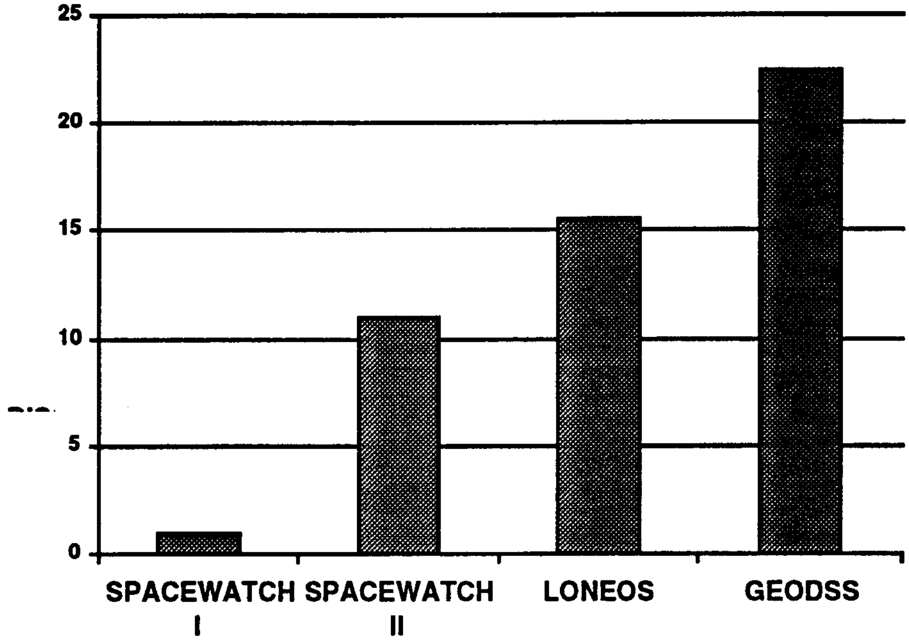

Figure 1. Near Earth object discovery rates for single telescopes in the northern hemisphere relative to Spacewatch I.

Conclusion: Future Possibilities

The resulting advances in these technologies make it possible to envision a more automated, production-oriented cataloguing than past and current efforts might imply. As shown in Figure 1,the projected system capabilities of a single GEODSS telescope upgraded with CCD technology should have more than 20 times the discovery rate of NEO's than the current SPACEWATCH. SPACEWATCH is the largest current contributor to NEO discovery. The Air Force is constructing a new, approximately four meter, very agile telescope (AEOS) on Maui at a cost of approximately $120 million. This and its predecessor (STAR FIRE at Albuquerque) might also have use in the characterization of NEO's.